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The effect of α-tocopherol and butylated hydroxyanisole on the colour properties and lipid oxidation of kavurma, a cooked meat product

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Abstract

Kavurma is a cooked meat product and is consumed sliced. The amount of animal fat in kavurma (30–40%) is higher than in other meat products; therefore, lipid oxidation and colour defects are a major problem during storage and in the market place. To preserve the quality characteristics of kavurma in markets antioxidants must be added and the product must be packaged and stored at low temperature. In this study, the effects of α-tocopherol and butylated hydroxyanisole (BHA) levels on lipid oxidation and colour deterioration of sliced and vacuum-packaged kavurma were investigated. Kavurma was made from beef meat and melted beef fat in 5 groups: No-added antioxidant, 50 mg/kg BHA, 100 mg/kg BHA, 50 mg/kg α-tocopherol and 100 mg/kg α-tocopherol. The kavurma produced was sliced (3–4-cm thick) and vacuum packed and stored at 4 °C for 300 days, and thiobarbituric acid reactive substance, pH, moisture, lightness, redness and yellowness values of sliced product were determined during storage. The use of antioxidants in kavurma production caused a significant ($P < 0.01$) decrease in the thiobarbituric acid reactive substances (TBARS) values. The lipid oxidative stability effect of the antioxidants was in following order: 100 mg/kg BHA > 100 mg/kg α-tocopherol > 50 mg/kg BHA = 50 mg/kg α-tocopherol > no-added antioxidant group. Also, TBARS values did not differ significantly ($P > 0.05$) between 0 and 300 days in the 100 mg/kg BHA and 100 mg/kg α-tocopherol groups. In addition, the no-added antioxidant group had lower lightness and yellowness values than all the antioxidant groups. Sliced and vacuum-packaged kavurma with added antioxidant showed greater colour and lipid oxidative stability during storage than kavurma to which no antioxidant was added.
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Keywords: Kavurma; Cooked meat; Antioxidant; Colour; Shelf-life

1. Introduction

Kavurma is a cooked meat product made from beef or mutton, beef fat and salt. Meats are diced (approximately 4 × 5 cm) and mixed with salt, and then cooked in animal fat using a double-sided steam cauldron. After cooking, the product is kept in almost anaerobic conditions and at low temperatures. Kavurma may be filled and chilled in large casings of 3–4 kg. Kavurma is also sold in slices or vacuum-packaged forms and has an average shelf life of 6 months (Anon., 1991, 2002; Gökalp, Kaya, & Zorba, 2004).

The amount of animal fat in kavurma is higher than other meat products; therefore, lipid oxidation is a major problem during storage. To preserve the quality characteristics of kavurma in the market place there is a need for it to be packaged and stored at low temperatures. Also, lipid oxidation can occur in kavurma during marketing and the risk of spoilage is increased with slicing. Variations such as colour defects, rancidity and

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spoilage due to inappropriate protection occur in sliced kavurma. Adding antioxidant and packaging, therefore, is necessary to extend shelf life, and to protect the quality properties of sliced kavurma (Gökalp et al., 2004; Kaya, 1995; Kaya & Gökalp, 1995). Lipid oxidation is a major deterioration reaction which often results in a significant loss of meat product quality. It is well known that lipid oxidation is positively correlated with pigment oxidation (Gray, Gomaa, & Buckley, 1996). The most obvious precaution to take against oxidative deterioration is to remove the source of oxygen. Vacuum packaging has been used to delay oxidation in processed meat products and to protect colour. In most cases, vacuum packing of meat or meat products affords very satisfactory protection against colour and rancidity problems (Ranken, 1994, chap. 11; Allen & Hamilton, 1994).

Cooking is a main process of Kavurma production. With cooking meats are even more vulnerable to oxidation, since antioxidative enzymes in the muscle, like catalase and superoxidase dismutase, may denature and lose their activity, while iron-containing proteins at the same time become a source of catalytic iron or, like myoglobin and hemoglobin, may be transformed into partly denaturated forms with peroxidase activity (Bertelsen, Jensen, & Skibsted, 2000, chap. 14; Kingston, Monahan, Buckley, & Lynch, 1998). Therefore, Tims and Watts (1958) reported that the cooking process leads to a dramatic increase in lipid oxidation in muscle and the development of "warmed-over" flavor of refrigerated cooked meats. Lee, Mei, and Decker (1996) reported that cooking causes thermal denaturation of antioxidant enzymes and enzyme inactivation is believed to contribute in part to lipid oxidation in cooked meats.

Antioxidants are substances that can delay the onset or slow the rate of oxidation of autoxidizable materials. The benefits of antioxidants in food storage have been studied extensively in recent years (Bekhit, Geesink, Ilian, Morton, & Bickerstaffe, 2003). Synthetic antioxidants, such as butylated hydroxyanisole (BHA) have been commonly used to suppress the formation of free radicals and prevent lipid oxidation and food spoilage. BHA has high solubility in animal fats. It also has good stability under the conditions encountered in many food-processing operations and gives good stability to a fried product (Allen & Hamilton, 1994; Coppen, 1994, chap. 5). α-Tocopherol is also a significant antioxidant and it can decrease lipid oxidation and colour changes in meat products and animal fats (Dziezak, 1986; Morrisey, Buckley, & Sheehy, 1994). The positive effect of α-tocopherol in the protection of precooked meats against off-flavor is generally acknowledged (Bertelsen et al., 2000, chap. 14).

The purpose of this study was to determine the effect of different antioxidants and/or their levels (control, 50, 100 mg/kg BHA, 50 mg/kg α-tocopherol and 100 mg/kg α-tocopherol) and storage (0, 30, 60, 90, 150 and 300 days) on the pH, TBARS and colour properties of sliced, vacuum packaged kavurma.

2. Materials and methods

Beef meat, melted beef meat fat and NaCl were used as the raw material for kavurma production. Commercial preparations of α-tocopherol [(±)-α-tocopherol, SIGMA] and butylated hydroxyanisole [2(3)-*t*-butyl-4-hydroxyanisole, SIGMA] were used as antioxidants.

Kavurma was manufactured (Fig. 1) according to the formulation reported by Anon. (1991) and Gökalp (1995): 700 g/kg beef meat, 280 g/kg melted beef fat, and 20 g/kg NaCl. Antioxidants were dissolved in the melted fats (55–60 °C) and added to the kavurma, and then mixed (Fig. 1).

Kavurma products [No-added antioxidant (control), 50, 100 mg/kg BHA, 50 mg/kg α-tocopherol and 100 mg/kg α-tocopherol] were sliced (3–4-cm thick) using a slicing machine at the end of processing. Sliced kavurma for each group was packaged automatically and thermally sealed by a Multivac packaging unit (Multivac A 300/16, Sepp Haggenmüller, D 87787 Wolfertschwenden, Germany) under vacuum. A vacuum bag OPAEVOH/PE (water vapor transmission rate 15 g/m^2/24 h/38 °C/, 90% RH, 1 atm; O_2 transmission rate 5 cm^3/m^2/24 h/23 °C, 50% RH, 1 atm; N_2 transmission rate 1 cm^3/m^2/24 h/23 °C, 50% RH, 1 atm; CO_2 transmission rate 23 cm^3/m^2/24 h/23 °C, 50% RH, 1 atm) was used. Sliced-packaged kavurma samples were stored at 4 °C for 300 days. The moisture, pH and thiobarbituric acid reactive substances (TBARS) values were observed at 0 and 300 days of storage. Colour properties (L^*, a^* and b^* values) of the samples also were measured at 0, 30, 60, 90, 150, and 300 days of storage. The moisture and pH values (with a pH meter, SCHOTT L 6880, Lab Star pH) in samples were determined according to the methods of Gökalp, Kaya, Tülek, and Zorba (2001). Lipid oxidation was measured as thiobarbituric acid reactive substances (TBARS). The TBARS assay is commonly used to measure the oxidative rancidity of meats and other fat containing food products. TBARS values of samples were determined according to the methods of Lemon (1975) and were expressed as μmol malonaldehyde per kg meat.

A Minolta Model tristimulus colorimeter (Minolta Chroma Meter Measuring Head CR-200, Minolta, Osaka, JAPAN) was used to objectively measure CIE Lab [where L^* measures relative lightness ($L^* = 0$ darkness, $L^* = 100$ lightness), a^* relative redness (+60 = red, −60 = green) and b^* relative yellowness (+60 = yellow, −60 = blue)]. Colour was measured on the Kavurma surface immediately after opening of the package. The measurements were repeated on four randomly selected locations on each sample.

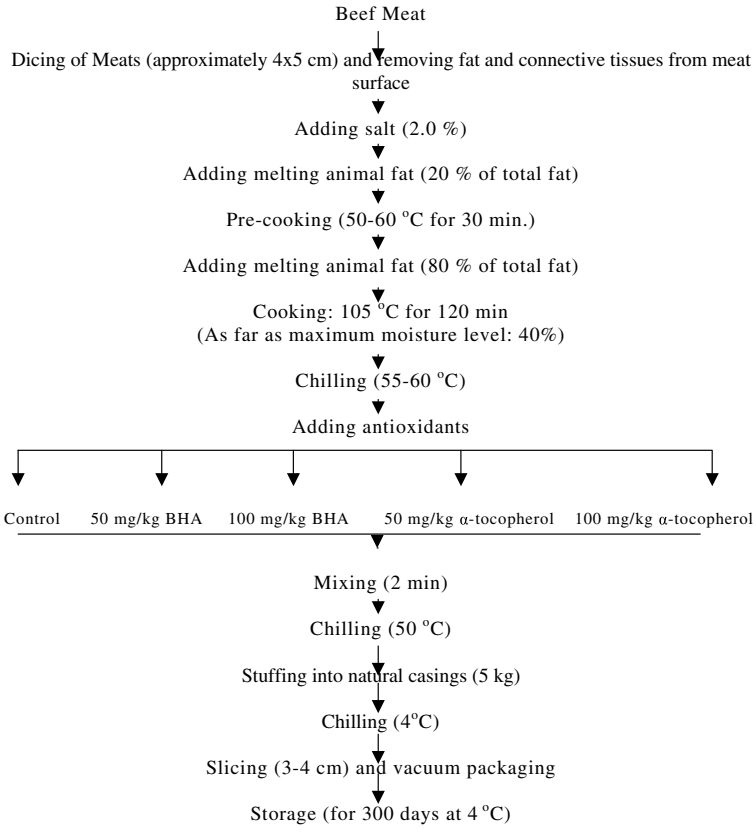

Fig. 1. The production process of kavurma.

Data were analyzed with the completely randomized design procedure using the SPSS (1996)SPSS/package. Differences between data were tested using Duncan's multiple range test (significance $P < 0.05$). The model included antioxidant (control, 50 mg/kg BHA, 100 mg/kg BHA, 50 mg/kg α-tocopherol and 100 mg/kg α-tocopherol) and storage period (0, 30, 60, 90, 150, and 300 days) as main effects, and all their interactions. The results of the statistical analyses are shown as mean values ± standard deviations in the tables.

3. Results and discussion

Moisture contents of the kavurma samples were as follows: 0 day; 37.91 ± 0.76–39.80 ± 1.08% and 300 days: 36.49 ± 0.72–38.81 ± 1.00%. There were no statistically significant differences between 0 day and 300 days values ($P > 0.05$). Also, there were no significant differences between the moisture values of the control and treatment groups ($P > 0.05$). The measured values were close to values reported in the literature. According to the kavurma standard (TS 978, Anon., 2002), the maximum moisture content of kavurma should be 40.0%. There has been some research on the amount of moisture in kavurma produced in Turkey. For instance, Tiryakioğ lu and Yücel (1995) found that the average moisture content in kavurma products in the market place in Bursa was 38.84%, while Cetin (2000) found that the moisture content in kavurma in the market place in Erzurum ranged from 27.37% to 58.39%.

Table 1 shows the pH and TBARS results of kavurma during storage. The pH values were not significantly affected by antioxidant treatment ($P > 0.05$). But, storage had an effect ($P < 0.05$) on the pH values of the control and 50 mg/kg α-tocopherol groups. pH values for these groups at 300 days were higher ($P < 0.05$) than at 0 day (Table 1). The effectiveness of antioxidants is dependent on pH (Xiong, Decker, Robe, & Moody, 1993). Vural and Öztan (1989a) reported that the pH values of kavurma were 6.15–6.45 (average: 6.26 ± 0.031). Cetin (2000) found that the average pH value in kavurma in the market place in Erzurum was 6.06, while Tiryakioğ lu and Yücel (1995) reported that the average pH value of kavurma was 6.39.

There was no significant difference ($P > 0.05$) in the values of TBARS in the sliced kavurma groups at 0 day. However, there were statistically significant ($P < 0.01$) differences in TBARS values between control and treatment groups at 300 days. At the end of the storage period, the lowest TBARS values were found in kavurma produced with 100 mg/kg BHA, while the highest TBARS values were in the kavurma produced without antioxidant (Table 1). TBARS values of sliced kavurma

Table 1
The pH and TBARS values of vacuum packed and sliced kavurma with or without antioxidant

Properties	pH		TBARS[A]	
Treatments	0 day	300 days	0 day	300 days
Control	6.21 ± 0.02[a]	6.32 ± 0.06[a]	6.74 ± 0.34[a]	18.50 ± 0.77[a]
50 mg/kg α-tocopherol	6.17 ± 0.07[a]	6.27 ± 0.14[a]	4.90 ± 1.53[a]	14.19 ± 0.08[b]
100 mg/kg α-tocopherol	6.26 ± 0.21[a]	6.30 ± 0.07[a]	7.90 ± 2.30[a]	9.79 ± 0.38[c]
50 mg/kg BHA	6.21 ± 0.07[a]	6.27 ± 0.04[a]	4.36 ± 1.91[a]	13.62 ± 1.19[b]
100 mg/kg BHA	6.28 ± 0.14[a]	6.30 ± 0.28[a]	4.08 ± 0.13[a]	5.67 ± 0.33[d]
Significance	NS	NS	NS	–[**]

NS: $P > 0.05$.
[a–d] Any two means in the same column having the same letters (0 or 300 days) are not significantly different ($P > 0.05$). On storage, the pH of the control and 50 mg/kg α-tocopherol increased significantly ($P < 0.01$), while the increase in TBARS value on storage was significant ($P < 0.01$) in all groups except those containing 100 mg/kg of antioxidant.
[A] μmol malonaldehyde/kg.
[**] $P < 0.01$.

Table 2
The pH and TBARS values of vacuum packed and sliced kavurma with or without antioxidant after 0 and 300 days of storage

Storage time	Control	α-tocopherol		BHA	
		50 mg/kg	100 mg/kg	50 mg/kg	100 mg/kg
pH					
0 days	6.21 ± 0.02[b]	6.17 ± 0.07[b]	6.26 ± 0.21[a]	6.21 ± 0.07[a]	6.28 ± 0.14[a]
300 days	6.32 ± 0.06[a]	6.27 ± 0.14[a]	6.30 ± 0.07[a]	6.27 ± 0.04[a]	6.30 ± 0.28[a]
Significance	*	*	NS	NS	NS
TBARS[1]					
0 days	6.74 ± 0.34[b]	4.90 ± 1.53[b]	7.90 ± 2.30[a]	4.36 ± 1.91[b]	4.08 ± 0.13[a]
300 days	18.50 ± 0.77[a]	14.19 ± 0.08[a]	9.79 ± 0.38[a]	13.62 ± 1.19[a]	5.67 ± 0.33[a]
Significance	**	**	NS	**	NS

[1] μmol malonaldehyde/kg, * $P<0.05$, ** $P<0.01$, NS: $P>0.05$.
[a,b] Any two means in the same column having the same letters in the same sections are not significantly different at $P>0.05$.

containing 100 mg/kg α-tocopherol or 100 mg/kg BHA did not differ significantly ($P > 0.05$) between 0 and 300 days of storage. However, storage had an effect ($P < 0.01$) on TBARS values in sliced kavurma containing 50 mg/kg α-tocopherol, 50 mg/kg BHA or no added antioxidant (control) (Table 2). α-Tocopherol protects highly oxidisable polyunsaturated fatty acids from peroxidation by reactive oxygen species produced by adjacent membrane-bound enyzmes (McCay & King, 1980). When tocopherol-supplemented meat is cooked, there is a significant increase in oxidative stability as reflected by TBARS values (Galvin, Lynch, Kerry, Morrissey, & Buckley, 2000; Lui, Scheller, Schaffer, Arp, & Williams, 1994; Lynch, Kerry, Buckley, Faustman, & Morrisey, 1999; Mikova, 2001, chap. 11). Pikul, Leszczynski, Bechtel, and Kummerow (1984) reported that the TBA numbers in cooked chicken increased between 1.9 and 2.7-fold compared to raw meat. Also, loss of protein functionality during storage is minimized by inhibition of lipid oxidation (Xiong et al., 1993). In a study on the use of tocopherol (30 mg/kg DL-α-tocopherol) as an antioxidant, Vural and Öztan (1989b) reported that the

Table 3
The L^*, a^* and b^* values of vacuum packed and sliced kavurma with or without antioxidant

Properties	L^* values	a^* values	b^* values
Treatment			
Control	44.39 ± 5.91[b]	6.14 ± 1.53[b]	5.63 ± 2.52[b]
50 mg/kg α-tocopherol	47.07 ± 4.51[a]	6.43 ± 1.80[b]	7.11 ± 2.08[a]
100 mg/kg α-tocopherol	46.28 ± 3.74[a]	5.96 ± 1.86[b]	7.25 ± 1.81[a]
50 mg/kg BHA	48.17 ± 3.27[a]	6.69 ± 1.94[ab]	7.46 ± 1.94[a]
100 mg/kg BHA	47.64 ± 3.47[a]	7.41 ± 1.91[a]	7.23 ± 2.25[a]
Significance	–[**]	–[**]	–[**]
Storage time			
0 day	47.89 ± 5.58[ab]	8.15 ± 1.61[a]	7.09 ± 1.69[bc]
30 days	45.66 ± 4.21[bc]	7.48 ± 1.56[ab]	6.02 ± 2.21[cd]
60 days	45.87 ± 3.99[bc]	6.77 ± 1.15[bc]	6.33 ± 1.83[cd]
90 days	47.04 ± 3.13[abc]	6.19 ± 1.83[c]	8.06 ± 2.10[ab]
150 days	44.37 ± 4.02[c]	6.22 ± 0.94[c]	8.74 ± 1.42[a]
300 days	49.42 ± 4.24[a]	4.34 ± 1.38[d]	5.37 ± 2.06[d]
Significance	–[**]	–[**]	–[**]

[a–d] Any two means in the same column having the same letters in the same sections (treatment or storage time) are not significantly different at $P > 0.05$.

TBA values of kavurma stored at 0 °C for 180 days were as follows: no-added antioxidant group; 0 day: 2.10, 180 days: 2.32 mg malonaldehyde/kg, and added antioxidant group: 1.41 and 1.61 mg malonaldehyde/kg, respectively. Dinç (1997) also reported that TBA values of kavurma increased during storage (0 days: 1.055, 90 days: 1.583 mg malonaldehyde/kg).

Colour is an important factor for consumer acceptance of cooked meat products. Shelf life and quality of cooked meat products are strongly influenced by initial meat quality, additives, packaging parameters and storage conditions. During cooking of meats, the globin is denatured and haemoglobin is formed (Gökalp et al., 2004). Lawrie (1998) reported that the colour complexes in cooked meat are denaturated haemoproteins where the protein may be one or other of several denatured proteins present, and not only globin. Table 3 shows the mean values and standard deviations for L^*, a^* and b^* values for the kavurma samples. There were significant ($P < 0.01$) differences between treatment groups, in terms of L^*, a^* and b^* values. The lowest L^* value was found in the control group, while no significant ($P < 0.05$) differences were observed between antioxidant groups. The highest a^* value was in the kavurma produced with 100 mg/kg BHA. There was a decrease ($P < 0.01$) in the a^* value during storage. The lowest a^* value was found at 300 days, while there was no statistically significant difference in a^* values between 60 and 150 days of storage (Table 3). An interaction ($P < 0.05$) of the treatment × the storage period was observed for a^* values, which is shown in Fig. 2. This figure illustrates that the fastest decrease in a^* values is in the control, 100 mg/kg α-tocopherol, and 50 and 100 mg/kg BHA groups had decreased a^* values between 150 and 300 days of storage. a^* Values for the 100 mg/kg α-tocopherol, 50 and 100 mg/kg BHA groups

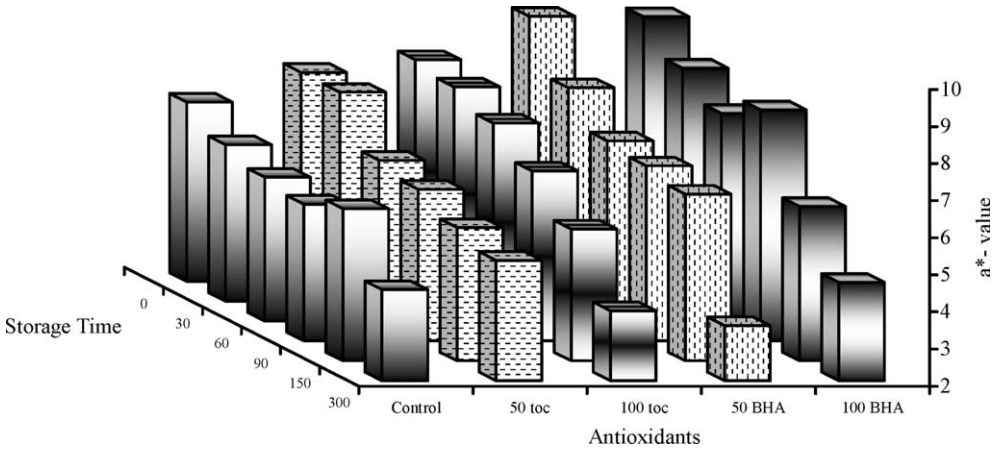

Fig. 2. Effect of antioxidants and storage time on the a^* value of kavurma (50 toc: 50 mg/kg α-tocopherol, 100 toc: 100 mg/kg α-tocopherol, 50 BHA: 50 mg/kg butylated hydroxyanisole, 100 BHA: 100 mg/kg butylated hydroxyanisole).

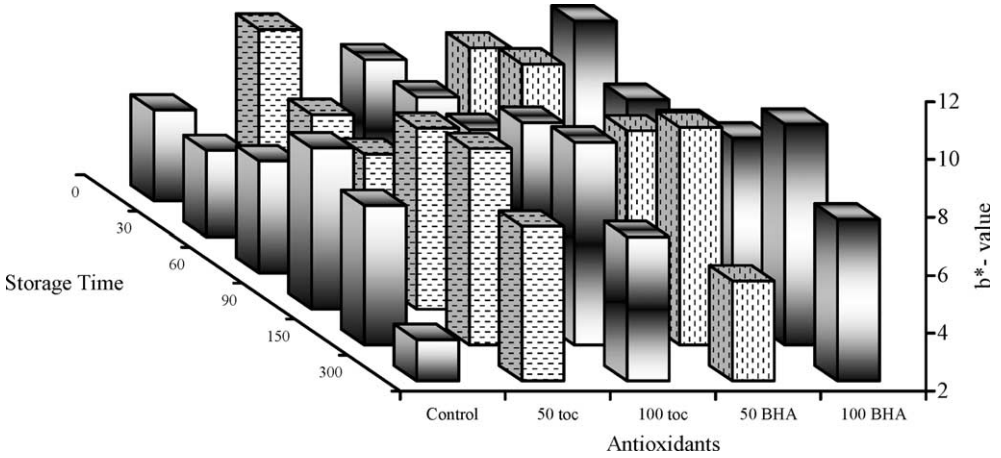

Fig. 3. Effect of antioxidants and storage time on the b^* value of kavurma (50 toc: 50 mg/kg α-tocopherol, 100 toc: 100 mg/kg α-tocopherol, 50 BHA: 50 mg/kg butylated hydroxyanisole, 100 BHA: 100 mg/kg butylated hydroxyanisole).

were higher between 0 and 90 days of storage than for the other groups (Fig. 2). Trout (1989) reported that the effect of pH on the percent myoglobin denatured was sufficient to produce obvious colour differences in cooked beef muscles. The no-added antioxidant kavurma had lower ($P < 0.05$) b^* values than those produced with antioxidants. This difference may be explained by the effectiveness of the antioxidants used for kavurma production. The highest b^* values during storage were observed at 90 and 150 days (Table 3). Also, an interaction ($P < 0.05$) between treatment and storage period was noted for b^* values, which is shown in Fig. 3. The fastest decrease in b^* values among treatment groups occurred between 150 and 300 days of storage (Fig. 3). Bekhit et al. (2003) reported that natural antioxidants had an effect on colour stability of beef patties. However, Lavella, Hunt, and Kropf (1995) reported that vitamin E did not affect the internal cooked colour, premature browning and persistent redness. With cooked meats, microbiological spoilage is slower and vacuum packaging gives significant protection against colour loss (Allen & Hamilton, 1994).

4. Conclusion

Our results show that lipid and colour stability in vacuum packaged, cooked kavurma was maintained by the addition of antioxidants. Thus, 100 mg/kg BHA or 100 mg/kg α-tocopherol can be used in kavurma production prevent lipid oxidation and colour changes during storage.

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